MISSOURI DEPARTMENT OF NATURAL RESOURCES
Missouri Geological Survey

US Army Corps of Engineers

MISSOURI WATER RESOURCES PLAN

Agricultural Needs Technical Workgroup

November 15, 2017, 1:00 p.m. to 4:00 p.m.

Kickoff and Workshop

Missouri Water Resources Plan

Welcome!

Jennifer Hoggatt

Director

Water Resources Center

Sherri Stoner

Chief of Planning

Water Resources Center

Agenda Overview

First Hour

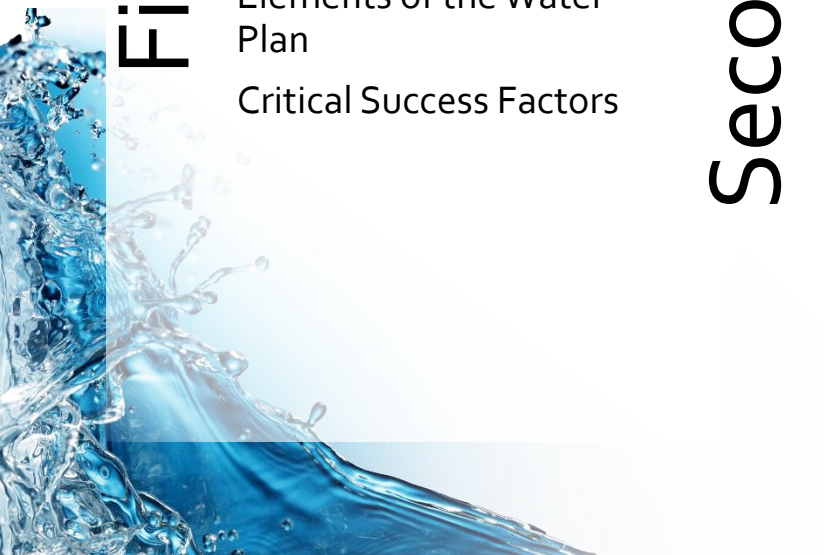
- Introduction and Meeting Format
- Missouri Department of Natural Resources Project Vision and Schedule
- U.S. Army Corps of Engineers Importance and Participation
- Organization Chart
- Scope and Core Elements of the Water Plan
- Critical Success Factors

Second Hour

- Water Resources Center Liaison Introductions
- Participant Introductions
- Communications
- Missouri Department of Natural Resources Water Plan website
- Break

Third Hour

- Technical Workgroup Roles
- Technical Workgroup Meetings
- Agricultural Needs Methodology Overview
- Next Steps
- Public Comments



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Missouri Water Resources Plan Vision

- Statutory Responsibility (640.415 RSMo):

  "The department shall develop, maintain and periodically update a state water plan for a long-range, comprehensive statewide program for the use of surface water and groundwater resources of the state, including existing and future need for drinking water supplies, agriculture, industry, recreation, environmental protection and related needs."

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Project Vision (MoDNR)

The Missouri Water Resources Plan is a long range, comprehensive strategy to:

- Provide an understanding of water resource needs
- Ensure the quantity of water resources meet future water demands
  - Identify future water supply shortfalls
  - Explore options to address water needs

Missouri Water Resources Plan Update: **Goals**

1. Gather public and stakeholder input to help identify needs and priority areas of water resource development.
2. Establish key stakeholder advisory and technical groups to help guide water plan development.
3. Develop an updated evaluation of current groundwater and surface water availability and develop projected water supply needs.
4. Produce an in-depth analysis of current and future consumptive, non-consumptive and agricultural water needs, and identify gaps in water availability based on water demand projections.
5. Identify water and wastewater infrastructure needs, and evaluate funding and financing opportunities.
6. Recognize water quality and assess how this affects water supply uses.
7. Understand areas where developing new and more sustainable water sources, better infrastructure, and more integrated water supplies can help to sustain water delivery.
8. To better understand regionally where future water gaps may exist, as studies have revealed in parts of southwest and northern Missouri.

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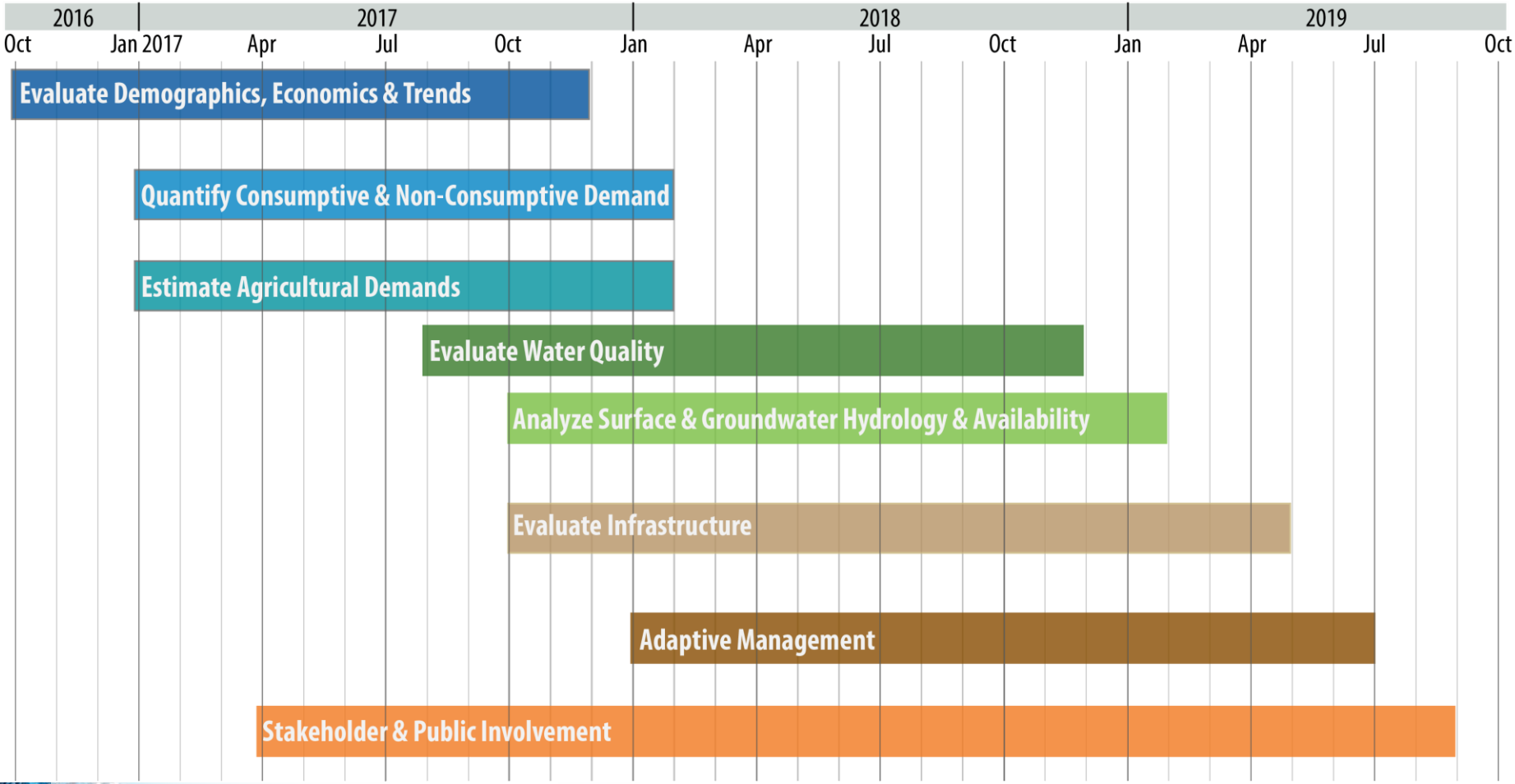
Missouri Water Resources Plan – Schedule



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USACE Partnership – Planning Assistance to States

Authority and Scope

- Section 22 of the Water *Resources Development Act (WRDA) of 1974, as amended, provides authority for the Corps of Engineers to assist the states, local governments, Native American Tribes and other non-federal entities, in the preparation of comprehensive plans for the development and conservation of water and related land resources.*

USACE Partnership (continued)

Planning Assistance to States Principles

- Typical studies are undertaken only at the planning level of detail
- They do not include detailed design for project construction
- Broad coverage – "water and related resource" planning
- Cost shared 50/50 with state, Tribal or local government
  - In-kind services can be used to meet 100 percent of non-federal contribution
  - Program annual ceiling is $30 million nationally, and $5 million per state

PAS – Types of Studies

- Water Supply and Demand
- Water Quality Studies
- Environmental Conservation/Restoration
- Wetlands Evaluation
- Dam Safety/Failure
- Flood Risk Management
- Flood Plain Management

Eau Galle River nutrient study for water quality

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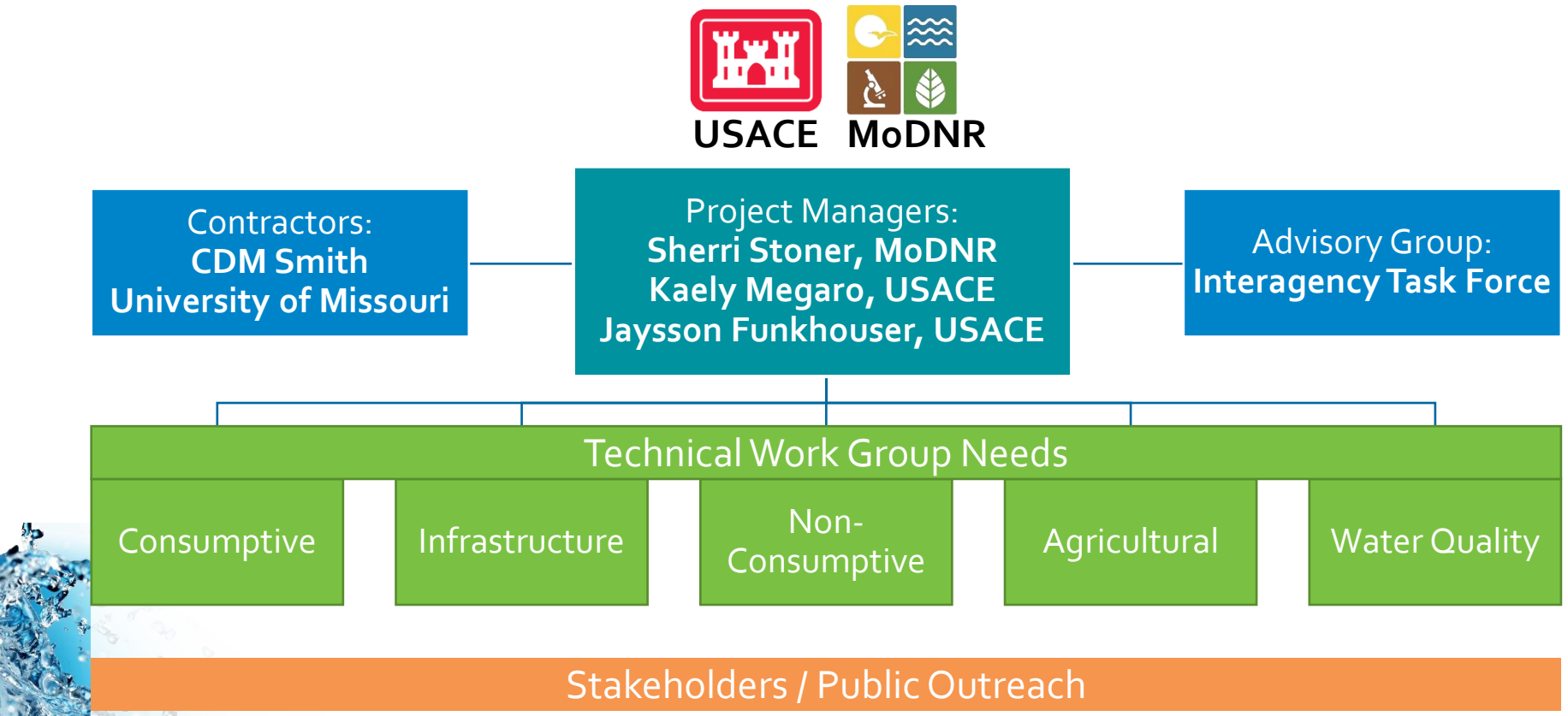
Missouri Water Resources Plan Organization Chart



Organization Roles and Responsibilities

USACE	MoDNR	CDM Smith University of Missouri
Technical Workgroup Liaisons/Spokesperson	Technical Workgroup Members	Stakeholders

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Water Resources Plan – Core Elements

- Demands
- Supply
- Infrastructure
- Water Quality
- Public and Stakeholder Involvement

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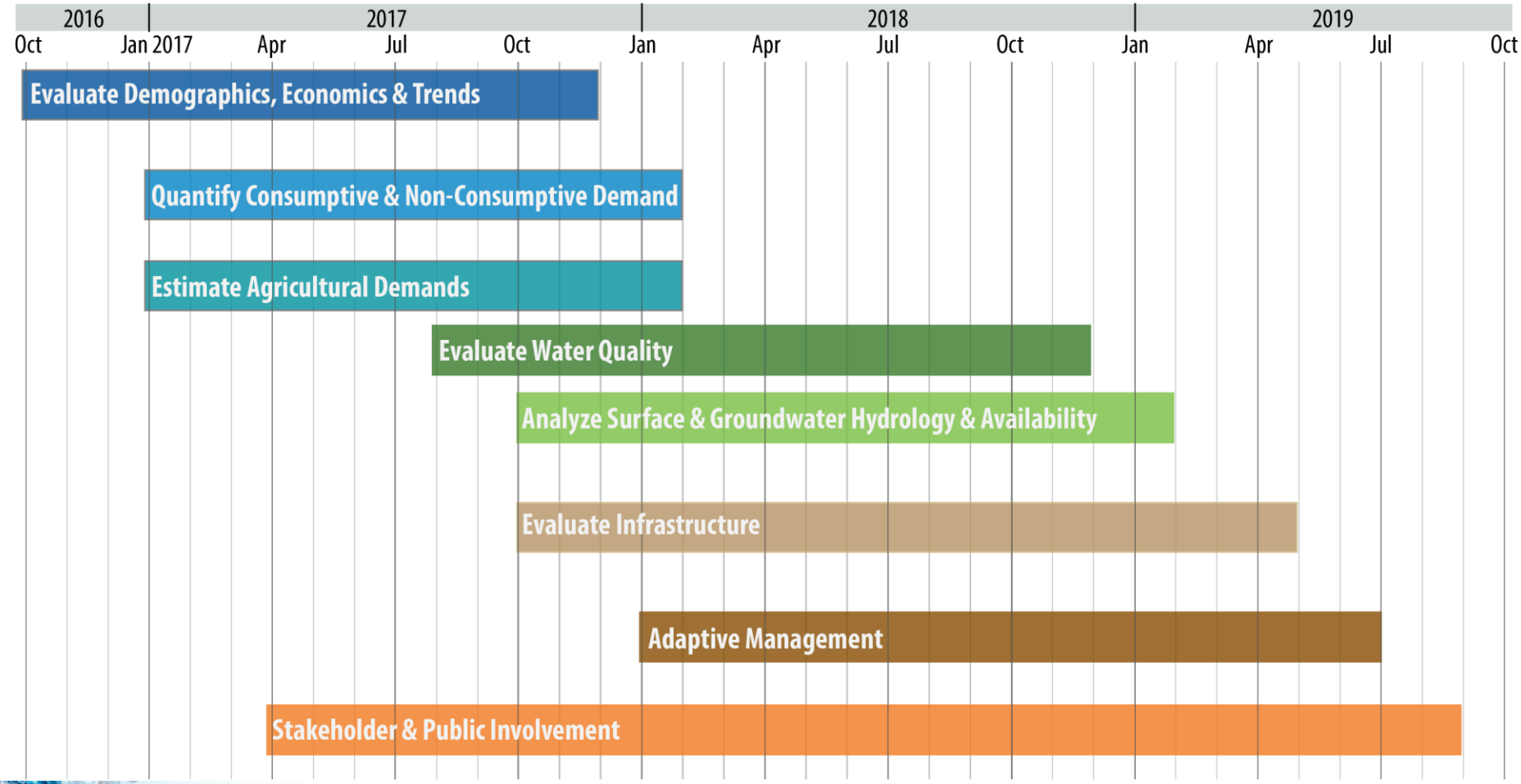
Water Resources Plan – Elements Schedule



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Water Resources Plan – Elements Schedule

Evaluate Demographics, Economics and Trends

- Evaluate current and projected population and other key demographic factors
- Evaluate the role of water in major economic sectors
- Analyze the social setting surrounding water management

Quantify Consumptive and Characterizing Non-Consumptive Demand

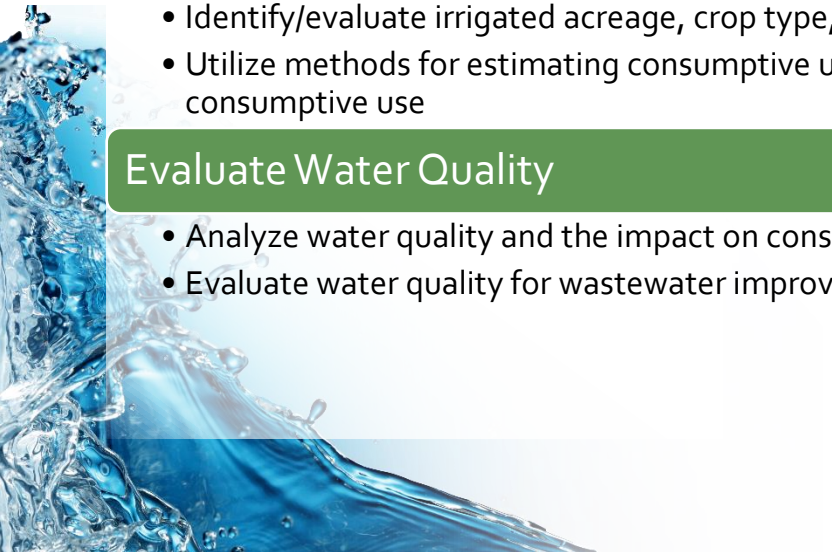
- Analyze demand studies and population estimates
- Estimate water resources sustainability and reliability
- Evaluate raw water providers production, wastewater treatment outfalls, reuse, conservation and efficiency, wholesale water contracts and direct flow storage
- Evaluate non-consumptive demands such as thermoelectric, navigation and water-based outdoor recreation

Estimate Agricultural Demands

- Identify/evaluate irrigated acreage, crop type, and livestock
- Utilize methods for estimating consumptive use, gross diversions, return flows, losses and non-beneficial consumptive use

Evaluate Water Quality

- Analyze water quality and the impact on consumptive water supply
- Evaluate water quality for wastewater improvements



Water Resources Plan – Elements Schedule

Analyze Surface and Groundwater Hydrology and Availability

- Analyze river basin hydrology and reasonable variations in hydrology
- Track and account water transfers between uses and between watersheds
- Estimate aquifer capacity, yield, sustainability and suitability for aquifer storage/recharge

Evaluate Infrastructure

- Analyze infrastructure, conservation, system efficiencies, conjunctive use, transfers and development of new supplies
- Analyze options to meet identified management objectives
- Estimate capital, Operations and Maintenance, and periodic costs
- Evaluate alternative rates and fee structures, cost-benefit analysis and non-traditional innovative funding strategies

Adaptive Management

- Identify major uncertainties related to the future of water in the State of Missouri
- Evaluate multiple planning scenarios and identify decision points

Stakeholder and Public Involvement

- Implement technical workgroups
- Facilitate stakeholder involvement meetings
- Gather public input

Missouri Water Resources Plan Update: **Define Water Supply Objectives**

- Sustainably meet municipal and industrial needs
- Sustainably meet agricultural needs
- Provide operational flexibility
- Protect the environment
- Promote cost effectiveness
- Identify water quality impacts on water supply uses
- Educate and engage residents, businesses and other stakeholders in water planning to 2060

Missouri Water Resources Plan Update: **Project Quality Process**

Step back from specific project details and look at the big picture

- What is the project going to accomplish?
- Why is it important?
- What do we need to ensure success?
- What might hamper our success and how do we deal with it?

Process is a team approach

- Active participation
- Develop a thorough understanding of the project
- Team commitment to project success

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Critical Success Factors

- Stakeholders
- Project Management
- Communication
- Technical

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Critical Success Factors

Stakeholders

- Collaboration and coordination across sectors, disciplines, groups, and project team members to develop a holistic plan. Representation for stakeholders across technical workgroups
- Leverage existing outreach efforts, optimize capacity of state water resources plan and best utilize information from each one
- Documentation and information sharing is public, open and easily accessible
- Establish mechanism for unsolicited outside public input
- Evaluate engagement beyond attendance; clearly incorporating feedback into final products
- Equitable representation of stakeholder groups and opportunity for feedback and buy-in on planning and methodology processes for analysis
- Design stakeholder engagement for "beyond the plan" to establish actual implementation of results
- Policy, programs and project recommendations generated by stakeholders, vetted and prioritized by MoDNR, incorporated into the water plan with implementation path forward
- Identify controversial and conflicting issues and establish facilitation for productive outcome of feedback

Critical Success Factors (continued)

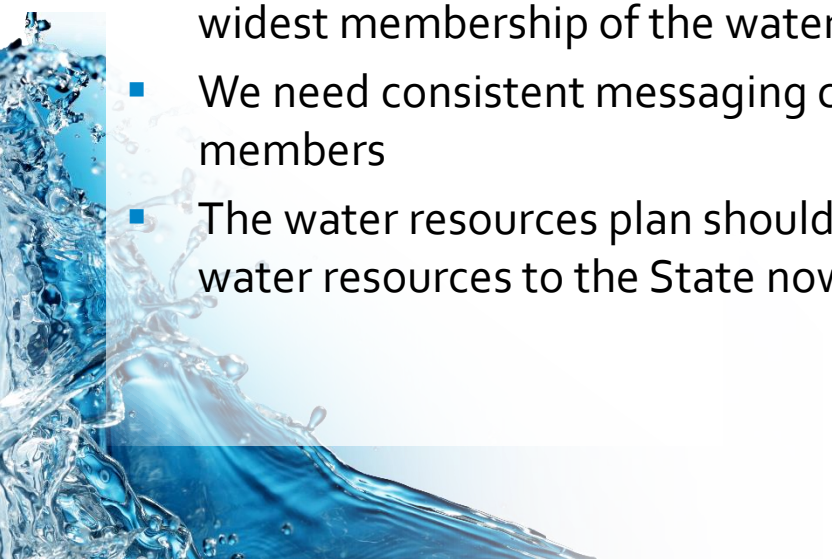
Project Management

- Communication through CDM Smith, MoDNR and USACE to disseminate throughout the groups and keep all team members informed and involved
- Understanding the established timeline and managing the expectations and needs to meet that schedule

Critical Success Factors (continued)

Communication

- Communication needs to be specific or tailored to the audience in question; we must know the audience and their issues and points of view
- Participants in the technical workgroups and the Interagency Task Force, stakeholders and the public need to finish the study with the feeling that their voices have been heard and that they contributed to the plan in a meaningful or material way
- We must find the right way to communicate with the appropriate web-based tools, in order to maximize our outreach and effectiveness in engagement of the widest membership of the water resources community
- We need consistent messaging coming from all water resources plan team members
- The water resources plan should result in raising the awareness of the value of water resources to the State now and in the future



Critical Success Factors (continued)

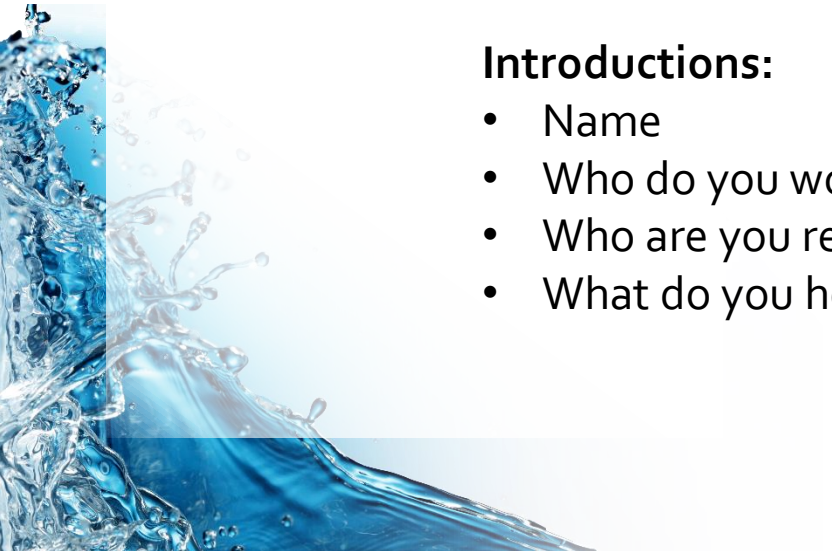
Technical

- Developing sound methodology and making sure this is clear to the stakeholders and readers of the report
- Have thorough quality assurance and quality control reviews in place
- Use best available data and determine where there is insufficient information
- Quantification of costs
- Sustainability
  - Priorities and components of high, medium and low projections (wet/dry, conservation, etc.)
- Missouri Water Resources Plan will document its findings

Water Resources Center Liaison Introductions

Technical Workgroups				
Consumptive	Infrastructure	Non-Consumptive	Agricultural	Water Quality
John Horton	**Michael Weller**	**Bryan Hopkins**	**Scott Kaden**	**Sherri Stoner**

Others from Contact List?



Introductions:

- Name
- Who do you work for?
- Who are you representing?
- What do you hope to get out of the process?

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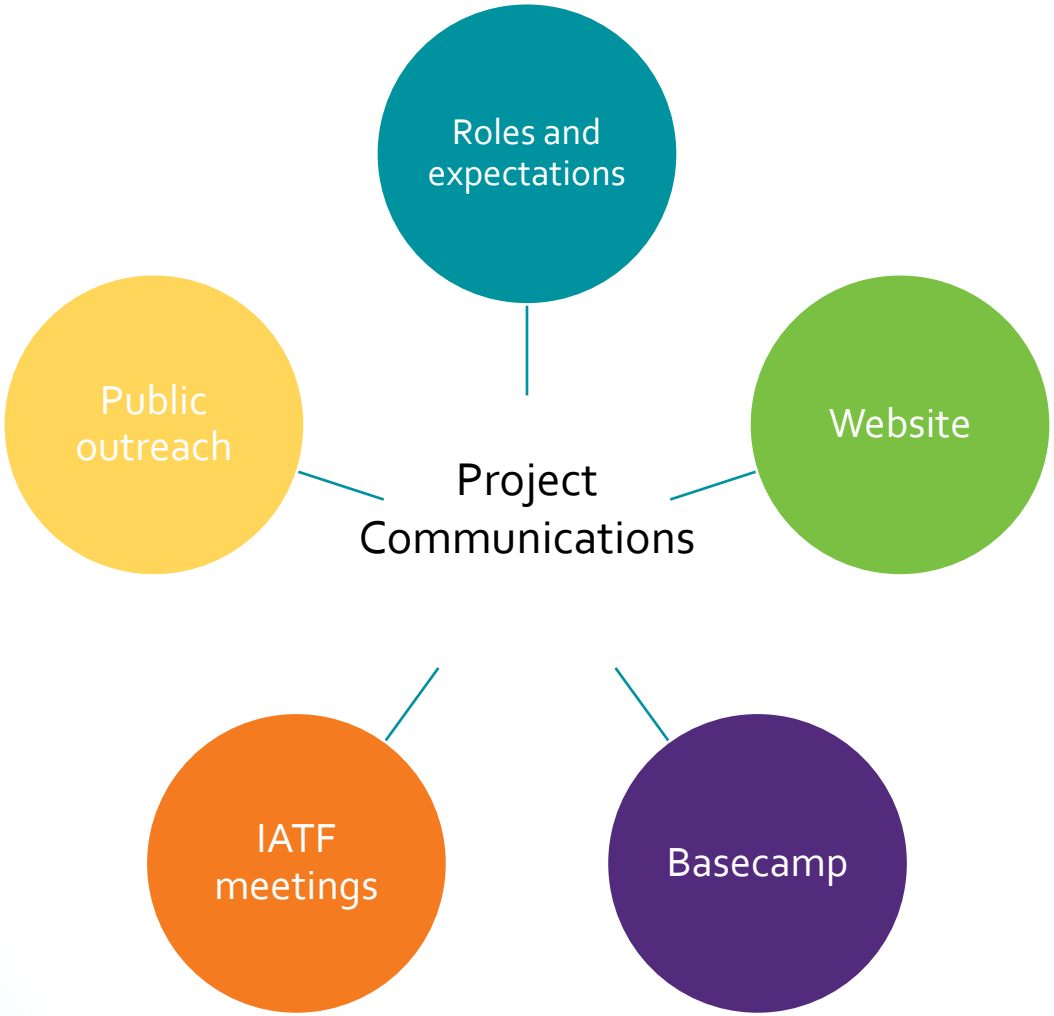
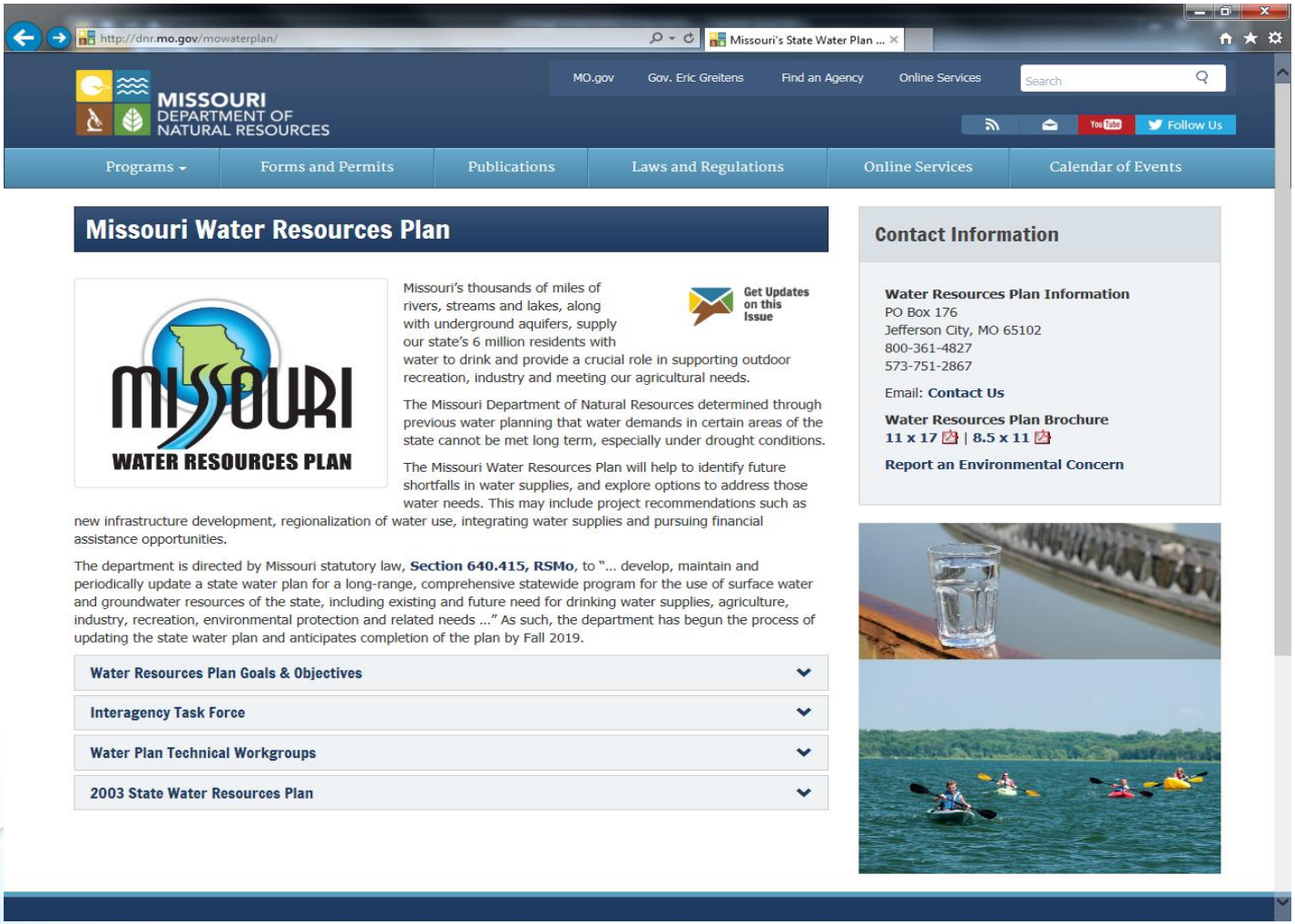
Project Communications



Missouri Water Resources Plan – Website



dnr.mo.gov/mowaterplan/

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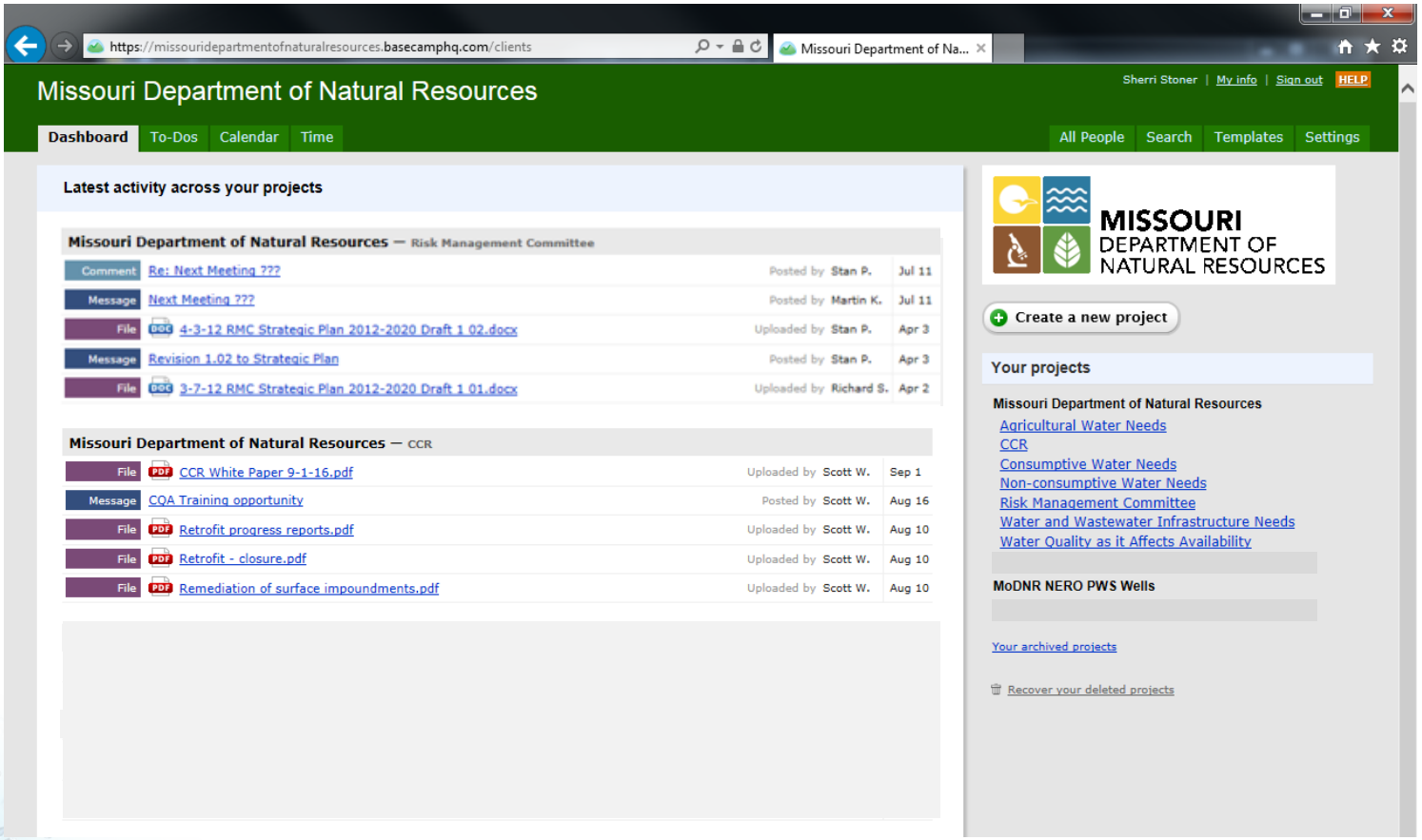
Missouri Water Resources Plan – Basecamp



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Public Outreach – MoDNR Base Presentation

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Public Outreach – Brochure

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Interagency Task Force (IATF) Updates

- Next IATF meeting is scheduled for:
  - **Date:** November 28, 2017
  - **Location:** Lewis and Clark State Office Building in Jefferson City, Mo.
  - **Time:** 9:00 a.m. to noon
- Topics to be discussed:
  - Water Resources Plan Status – CDM Smith
  - Technical Workgroups Update – Workgroup Spokesperson

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Identify Technical Workgroup Spokesperson

- Define the process to nominate and elect a spokesperson for each Technical Workgroup

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Technical Workgroup Role – Define

- Define the Technical Workgroups

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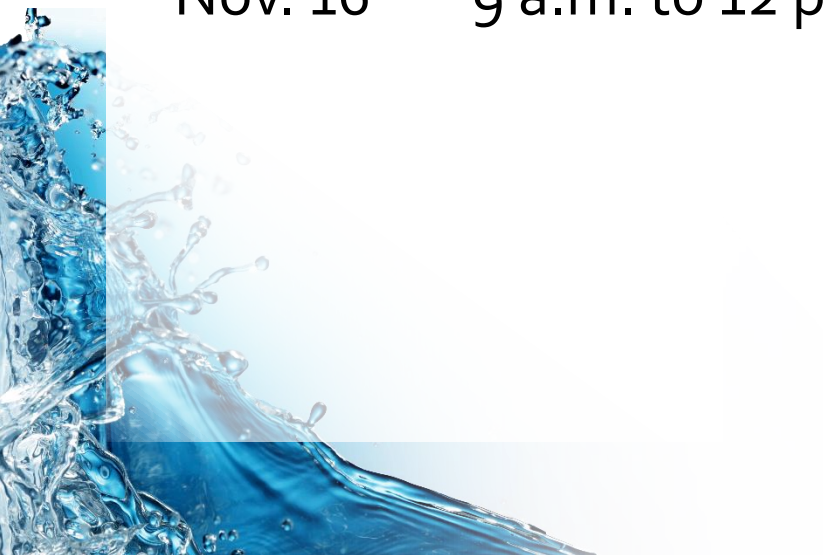
Technical Workgroup Role – Rules

- Define the Technical Workgroup Rules

Technical Workgroup Role – First Meetings

November 14-16, 2017, in Roaring River Conference Room, 1730 East Elm Street, Jefferson City

Nov. 14	9 a.m. to 12 p.m. – Consumptive Needs
	1 p.m. to 4 p.m. – Infrastructure Needs
Nov. 15	9 a.m. to 12 p.m. – Non-Consumptive Needs
	1 p.m. to 4 p.m. – Agricultural Needs
Nov. 16	9 a.m. to 12 p.m. – Water Quality Needs



Technical Workgroup Role – Future Meetings

February 6-8, 2018, in Roaring River Conference Room, 1730 East Elm Street, Jefferson City

Feb. 6	9 a.m.to 12 p.m. – Consumptive
	1 p.m. to 4 p.m. – Infrastructure
Feb. 7	9 a.m. to 12 p.m. – Non-Consumptive
	1 p.m. to 4 p.m. – Agriculture
Feb. 8	9 a.m. to 12 p.m. – Water Quality

May 15-17, 2018, in LaCharrette Conference Room, Lewis and Clark State Office Building, Jefferson City

May 15	9 a.m. to 12 p.m. – Consumptive
	1 p.m. to 4 p.m. – Infrastructure
May 16	9 a.m. to 12 p.m. – Non-Consumptive
	1 p.m. to 4 p.m. – Agriculture
May 17	9 a.m. to 12 p.m. – Water Quality

August 14-16, 2018, in LaCharrette Conference Room, Lewis and Clark State Office Building, Jefferson City

Aug. 14	9 a.m. to 12 p.m. – Consumptive
	1 p.m. to 4 p.m. – Infrastructure
Aug. 15	9 a.m. to 12 p.m. – Non-Consumptive
	1 p.m. to 4 p.m. – Agriculture
Aug. 16	9 a.m. to 12 p.m. – Water Quality

Technical Workgroup Role – Meetings

- Coordination with other Technical Workgroups

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Technical Workgroup Role – Participation

- Ask that members of the Technical Workgroups provide additional suggestions and recommendations to be considered in the process

Technical Workgroup Meetings

- Present current status of the Water Resources Plan – Overall
- Present the methodology for each element
- Present the status of the tasks as part of each element of the Plan
- Identify specific topics for Technical Workgroup input

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Agricultural Needs

Objectives

- Evaluate historical monthly water use of livestock and irrigated crops by county in the State of Missouri
- Project the monthly volume of water needed for irrigation and livestock for each county to 2060

Availability of Irrigation Data

- No state or county data available for irrigation water use by crop
- USDA irrigation data only provides acreage and crop type by county
- Therefore, water use must be estimated, not tabulated

Note: 2010 USGS National Report lists U.S. county water-use estimations in millions of gallons per day (heavily reliant on Major Water Users Database – known to under-estimate)

Irrigation Estimation Assumptions

- Irrigation applied to meet site-specific crop water demand
- Crop water demand is calculated on a monthly basis
- Crop water demand is equal to the difference between plant evapotranspiration and effective precipitation

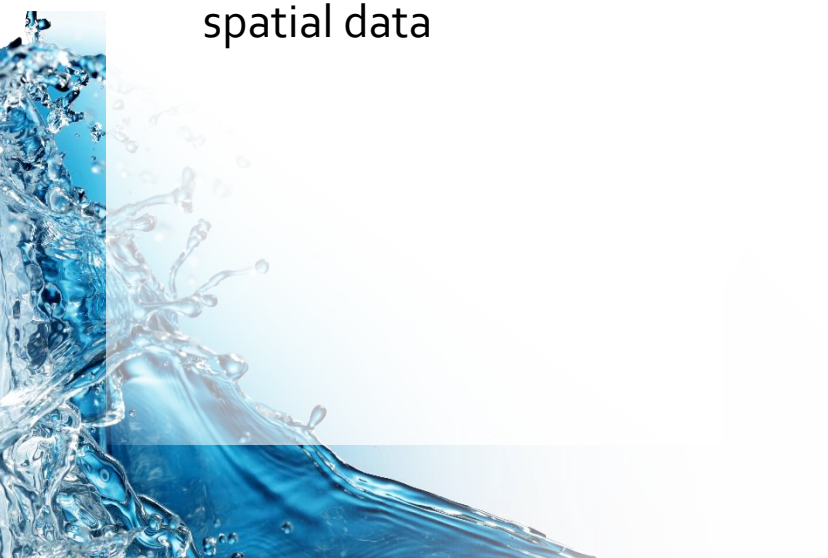
Irrigation Estimation Data Sources

Data Type	Data Source
Crop acreage	2012 USDA Census of Agriculture
County rankings by crop	2012 USDA Census of Agriculture
Crop planting/harvest estimates	Missouri Crop Resource Guide
Crop evapotranspiration coefficients	FAO
Missouri crop regions	Missouri Crop Resource Guide
County-level temperature data	High Plains Regional Climate Center
County-level precipitation data	High Plains Regional Climate Center

Crops Included in Study

- Grain Corn
- Soybean
- Cotton
- Rice
- Silage Corn
- Hay
- Sorghum
- Wheat
- "Vegetables"
- "Orchards"
- Sod
- Grass Seed

* "Berry" category removed due to very low (<300) acreage and limited spatial data



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Estimating Irrigated Acres

- Confirm crop acreages and explore datasets regarding percentage of irrigated acres for each crop by county
- Using the county data available, calculate the average percentage of irrigated acres by crop and region
- If county is missing irrigated acres for a crop, estimate using the total acres and regional crop average

Crop Irrigation Percentage by Region

Region	Grain Corn	Soybean	Cotton	Rice	Wheat	Hay/ Pasture	Silage Corn
North-West	3.57	2.89	0	0	0	0	.03
North-Central	1.45	0.66	0	0	0.15	0.18	0
North-East	3.41	1.21	0	0	0	0.27	0.07
Central-West	2.87	0.74	0	0	0.03	0.33	0
Central	4.35	1.84	0	0	0	0.51	1.62
Central-East	0.99	0.36	0	0	0.39	0.14	0
South-West	6.26	3.10	0	0	0.28	0.44	0
South-Central	8.43	12.63	0	6.25*	0.16	1.01	0
South-East	57.84	36.76	47.94	100	18.41	2.38	0

*Large standard deviation because only one county in region produces rice; 100 percent of rice is irrigated

Estimating Crop Water Use

- Calculate the reference evapotranspiration (ET) by county using the Hargreaves' Method (temperature method)
- Obtain crop coefficient values (3-growing periods; FAO data)
- Estimate planting date by crop and county according to the 50 percent planting and harvest dates provided by the *Missouri Crop Resource Guide*

"Vegetable" Crop Water Use

- For irrigation acreage data, vegetables are compiled into a single category
- Total acreage data does provide individual crop types
- Total acreage data is used to get relative percentage of each crop
- Crop coefficients, growth stage length, and planting date are estimated from a weighted average

"Vegetable" Crops

Vegetable	Acres	Percent of Total Harvest
2012 Total Irrigated Vegetables:	12,799	
2012 Total Vegetables:	20,213	
Snap Beans:	1,479	7.3
Cucumbers:	612	3.0
Peas:	623	3.1
Potatoes:	9,056	44.8
Pumpkins:	1,043	5.2
Sweet Corn:	2,325	11.5
Watermelons:	2,744	13.6

"Orchard" Crops

- Crops have county-level acreage, but no irrigation data
- USDA NASS lists 2,872 irrigated acres for the general "Orchard" category
- Acreage is dominated by improved pecans, native pecans, apples, peaches and grapes

"Orchard" Methodology

- Calculate regional average irrigation percentage for "Orchards"
- County-level acreage data for each individual crop
- Assume all "Orchard" crops receive the same irrigation percentage
- Use county-specific irrigation percentage if available, otherwise, use the regional irrigation percentage

Example of Grain Corn Planting Dates from *Missouri Crop Resource Guide*

Date	North West	North Central	North East	Central West	Central	Central East	South West	South Central	South East
Baseline (Averaged 1981-2010):	8-May	8-May	15-May	1-May	8-May	8-May	1-May	1-May	23-Apr
2012:	8-May	8-May	15-May	1-May	1-May	8-May	1-May	1-May	23-Apr
2011:	8-May	8-May	15-May	1-May	1-May	8-May	1-May	1-May	23-Apr
1988:	8-May	8-May	8-May	8-May	8-May	8-May	1-May	8-May	23-Apr
1980:	15-May	15-May	22-May	15-May	22-May	22-May	15-May	22-May	1-May
1953*:	8-May	8-May	15-May	1-May	8-May	8-May	1-May	1-May	23-Apr
1952*:	8-May	8-May	15-May	1-May	8-May	8-May	1-May	1-May	23-Apr

* Uses baseline data; as data did not extend this far back

Estimating Crop Water Use

- Calculate actual Crop ET by county and crop on a monthly basis, using crop coefficient and estimated regional season
- Calculate "effective precipitation" by county on a monthly basis, using the Crop ET and total precipitation
- Subtract each county's actual ET from the "effective precipitation" to calculate the total irrigation volume

Irrigation Estimation Procedure

- Multiply the volume of irrigation for each county by the irrigated acres for each crop in the county
- Divide total volume by the average efficiency of the regional irrigation methods to estimate the total water use
- Partition this volume according to the percentage of groundwater versus surface water in the county

(Estimates provided by University of Missouri – College of Agriculture, Food and Natural Resources and MU Extension)

Irrigation Efficiency

Irrigation Style	Efficiency
Sprinkler	80%
Surface (Furrow)	50%
Micro-Irrigation	90%

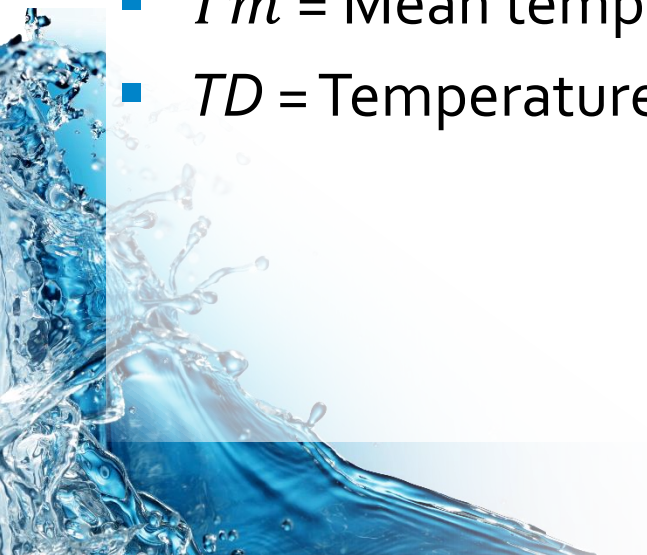
Summary of Irrigation Equations

- Potential evapotranspiration (Hargreaves' Method)
- Crop water requirement
- Effective precipitation
- Irrigation requirement

Potential Evapotranspiration (Hargreaves' Method)

$$PET = .0023 \times RA \times (Tm + 17.8) \times TD^{0.5}$$

- *PET* = Potential evapotranspiration (mm/day)
- *RA* = Extra-terrestrial radiation (mm/day) (interpolated from latitude)
- Tm = Mean temperature (°C)
- *TD* = Temperature difference (°C) = T(max) – T(min)



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Extraterrestrial radiation (expressed in equivalent evaporation rate (mm/day))

	Jan. RA	Feb. RA	Mar. RA	Apr. RA	May RA	Jun. RA	Jul. RA	Aug. RA	Sep. RA	Oct. RA	Nov. RA	Dec. RA
36° N	7.4	9.4	12.1	14.7	16.4	17.2	16.7	15.4	13.1	10.6	8	6.6
38° N	6.9	9	11.8	14.5	16.4	17.2	16.7	15.3	12.8	10	7.5	6.1
40° N	6.4	8.6	11.4	14.3	16.4	17.3	16.7	15.2	12.5	9.6	7	5.7
42° N	5.9	8.1	11	14	16.2	17.3	16.7	15	12.2	9.1	6.5	5.2

Crop Water Requirement

$$CWR = K_c \times PET$$

- CWR = Crop water requirement (mm/month)
- K_c = Crop ET coefficient (from FAO)
- *PET* = Potential ET (mm/month)

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Effective Precipitation

$$P_{eff} = f(D) \times (1.25 \times {P_t}^{0.824} - 2.93) \times 10^{.000955 \times ET_c}$$

- P_{eff} = Precipitation available for plants (mm/month)
- $f(D)$ = Correction factor based on soil moisture properties
- P_t = Total precipitation (mm/month)
- ET_c = Crop ET (mm/month)

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Irrigation Requirement

$$IR = \frac{CWR - P_{eff}}{Eff}$$

- *IR* = Irrigation requirement
- *CWR* = Crop water requirement
- P_{eff} = Effective precipitation
- E*ff* = Irrigation efficiency

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Availability of Livestock data

- Census of Agriculture provides no water use data for livestock, therefore, it is estimated based on reported livestock numbers for each category at the state and county level

Note: 2010 USGS National Report lists U.S. county water-use estimations in millions of gallons per day (heavily reliant on Major Water Users Database – known to under-estimate)

Livestock Water Use Estimation Assumptions

- Livestock water demand is calculated on a daily basis
- Average daily water use for each livestock category was obtained from literature
- Each livestock category has a fixed number of water-use days per year

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Livestock Water-Use Estimation Procedure

- Estimate the livestock number for each county
- Estimate the average daily water use for each livestock category
- Multiply average daily water use by number of days water was used to get annual water use
- Estimate the percentage of groundwater versus surface water for livestock water use by county

Livestock Annual Water Use Calculation

$$Annual\ Water\ Use = (Avg.\ Daily\ Water\ Use) \times (\#of\ Animals) \times (\#of\ Days)$$

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Livestock Water Use

- Inventory and sale numbers from Ag Census data 1997, 2002, 2007, and 2012
- Daily water use for each livestock category and number of days that livestock category is owned (consume water)

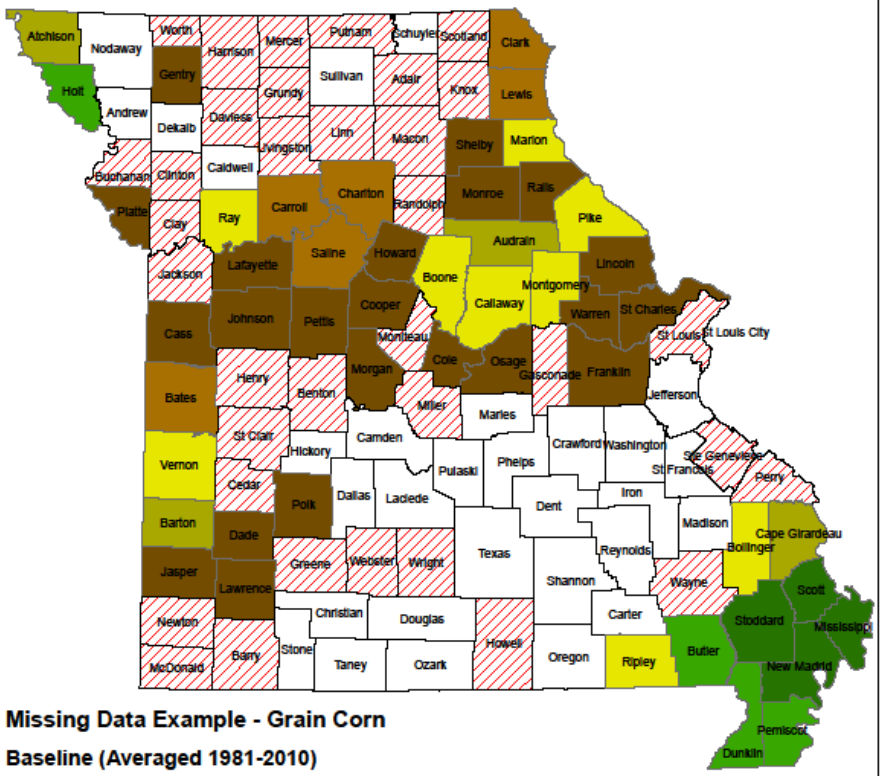
Daily Water Use	Other Cattle	Beef	Milk Cows	Swine for Breeding	Other Swine	Goat	Sheep	Broilers	Pullet	Layers	Turkey	Horses
Gallon/ Day	18.000	22.750	30.000	6.000	3.000	1.250	2.000	0.060	0.040	0.045	0.092	11.000
Days Owned	183	365	365	365	183	183	365	84	183	365	120	365

Method for Estimating Undisclosed Data

- Counties with missing data typically still provide their state ranking, thus the missing data is estimated using linear interpolation between the preceding and subsequent counties
- Confirmed by comparing listed state totals to our calculated total

Example	Top 10 County in Production of							
Ranking	Cattle and Calves	Hog	Broiler	Pullet	Layers	Turkey	Sheep and Lamb	Horse
1	Lawrence	Mercer	Barry	Newton	Newton	Morgan	Howard	Webster
2	Polk	Vernon	Newton	Johnson	Johnson	Lawrence	Vernon	Greene
3	Newton	Sullivan	McDonald	Webster	Lincoln	Miller	Laclede	Boone
4	Moniteau	Putnam	Pettis	Barry	Barry	Moniteau	Harrison	Lawrence
5	Barry	Gentry	Scott	Vernon	McDonald	Osage	Jefferson	Newton
6	Howell	Daviess	Stoddard	Lawrence	Pettis	Barry	Howell	Franklin
7	Webster	Miller	Lawrence	Pettis	Lawrence	Newton	Lafayette	Christian
8	Wright	Saline	Morgan	Stoddard	St. Francois	Jasper	Audrain	Cass
9	Johnson	Audrain	Benton	McDonald	Benton	Polk	Webster	Laclede
10	Texas	Monroe	Stone	Mississippi	Scott	Stone	Wayne	Polk

Example of Missing Data - Grain Corn



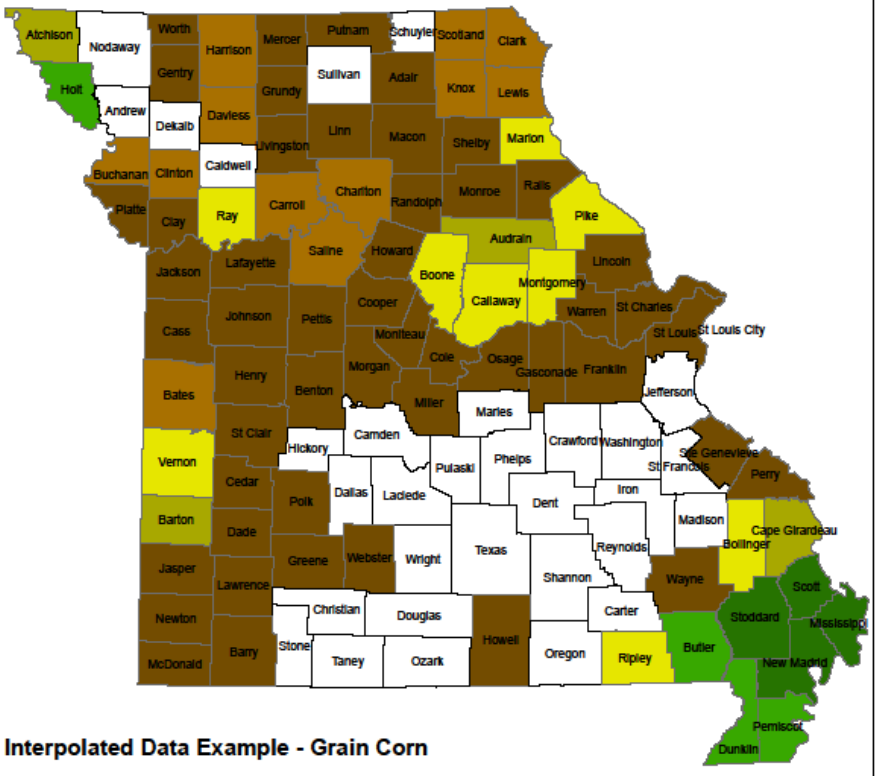
Missing Data Example - Grain Corn

Baseline (Averaged 1981-2010)

Grain Corn Irrigation (Acre-ft/year)

- No Irrigation Acreage Data
- 0
- < 800
- 800 - 1,500
- 1,500 - 2,200
- 2,200 - 6,500
- 6,500 - 16,000
- 16,000 - 51,431

Example of Interpolated Data - Grain Corn



Interpolated Data Example - Grain Corn

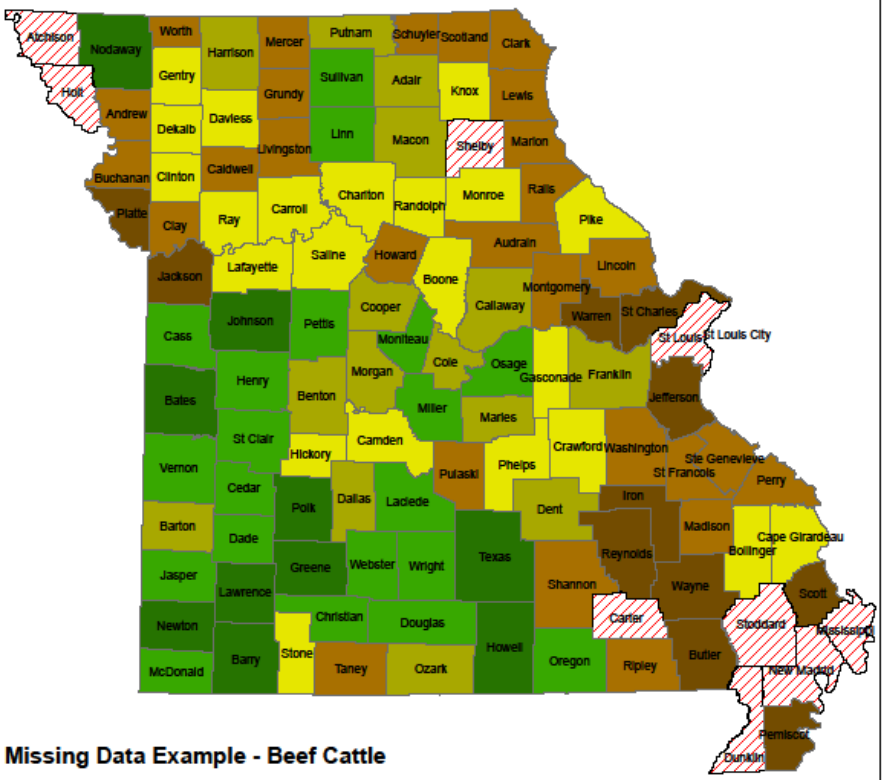
Baseline (Averaged 1981-2010)

Annual Volume (acre-ft)

- 0
- < 800
- 800 - 1,500
- 1,500 - 2,200
- 2,200 - 6,500.
- 6,500 - 16,000
- 16,000 - 51,431

Source: USDA 2012 Census of Agriculture

Example of Missing Data - Beef Cattle



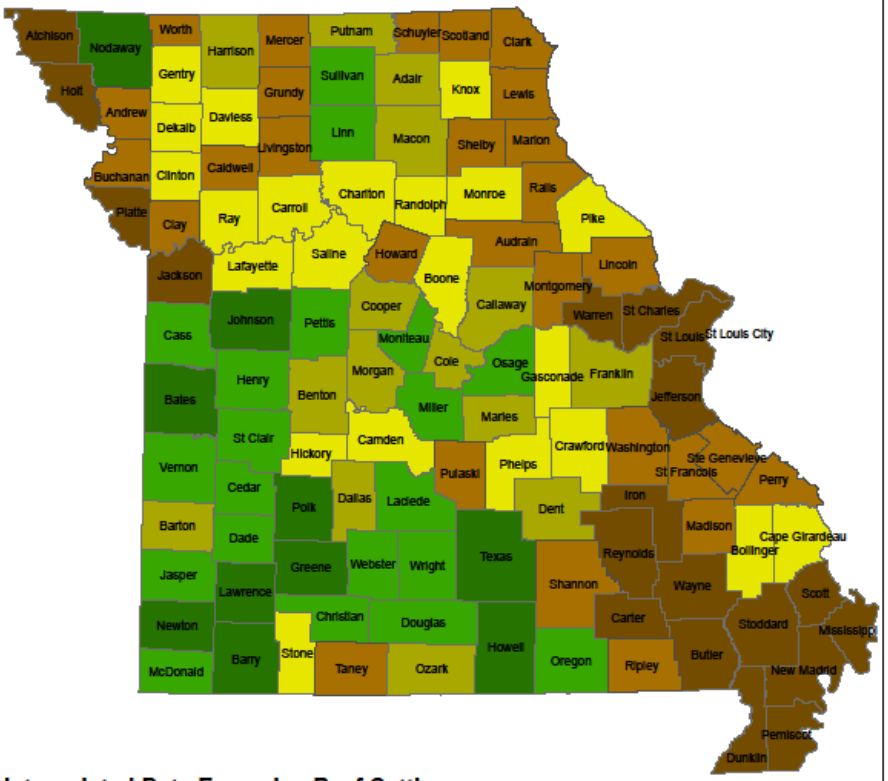
Missing Data Example - Beef Cattle

1997 Example Data

# of Beef Cows

- Missing County Data - Beef Cows
- < 8,000
- 8,000 - 14,000
- 14,000 - 18,500
- 18,500 - 25,000
- 25,000 - 32,000
- 32,000 - 45,721

Example of Interpolated Data - Beef Cattle



Interpolated Data Example - Beef Cattle

1997 Example Data

# of Beef Cows

- < 8,000
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Source: USDA 2012 Census of Agriculture

MISSOURI WATER RESOURCES PLAN

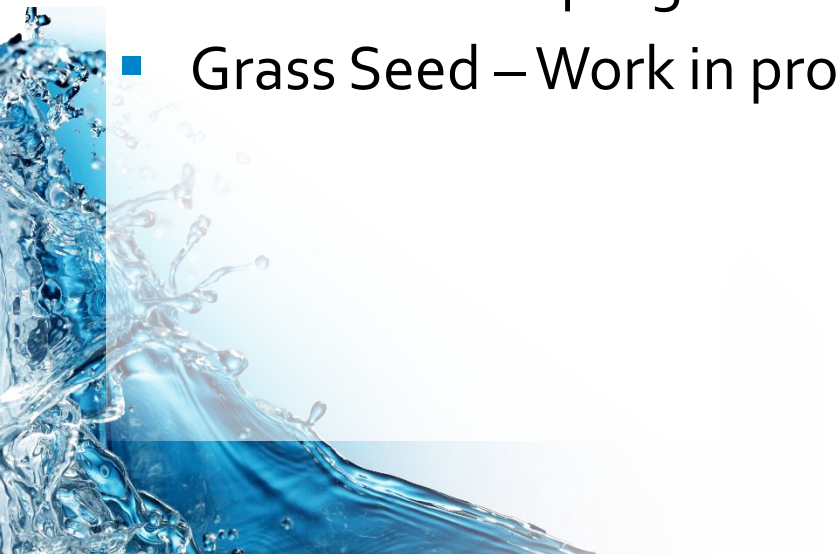
Total Irrigated Acres by Crop Type

Crop	Reported (2012 USDA NASS)	Sum of Reported Counties (2012 USDA NASS)	Sum of All Counties (Using Interpolation)
Grain Corn	327,339	323,306	341,141
Soybean	396,331	392,838	420,935
Cotton	219,595	216,037	218,190
Rice	174,559	173,784	173,784
Wheat	37,921	35,844	39,046
Haylage	9,901	6,208	13,258
Silage Corn	2,252	365	648

Highlighted counties indicate interpolation was not sufficient to provide estimations for every county. These counties will need to be estimated by local field experts.

Crops/Counties Still Requiring Acreage Estimation

- Cotton – Mississippi
- Rice – Bollinger and Cape Girardeau
- Sorghum – Cape Girardeau, Scott and Texas
- "Vegetables" – Work in progress
- "Orchards" – Work in progress
- Sod – Work in progress
- Grass Seed – Work in progress



Future Projection

Sources of water use for livestock:

Option 1: Maximum number

- The highest reported number of livestock for every category in each county was obtained using Ag Census data for 1997, 2002, 2007, and 2012. Historical maximum numbers are assumed to be the inventory for 2060. Livestock inventory from 2012 to 2060 was extrapolated using linear interpolation.

Option 2: FAO projection

- Livestock inventory from 2012 to 2060 obtained using the annual rate of change for each livestock group reported by FAO.

Option 3: USDA projection

- Livestock inventory from 2012 to 2060 obtained using the annual rate of change for each livestock group as reported by USDA.

Future Projection

- A “wet” and “dry” scenario will be defined and used to show the expected range for future projections

Next Steps

MISSOURI WATER RESOURCES PLAN

Public Comments

MISSOURI WATER RESOURCES PLAN

Thank You